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REVIEW.

MEASURES OF THE DOUBLE STARS CONTAINED IN THE MENSURÆ MICROMETRICÆ OF F. G. W. STRUVE COLLECTED AND DISCUSSED . . . By THOMAS LEWIS. London: Royal Astronomical Society, Burlington House. 1906.

The 2,640 double stars contained in STRUVE'S great work, familiarly known as the *Mensuræ Micrometricæ,* have, since its publication in 1837, furnished a large proportion of the material for the measures and studies of all double-star observers. Fully one hundred different professional and amateur astronomers have devoted some portion of their time to these stars, and the papers relating to them are widely scattered through the astronomical and other scientific journals and the transactions of scientific societies. To collect these papers, present their contents within the limits of a single volume in such form as to show the nature of the relation existing between the stars of these 2,640 systems, and discuss in more detail the more interesting ones, as well as some general problems relating to double stars, is the task Mr. LEWIS set for himself in preparing the work now under review. Both by his long experience as an observer and computer of orbits of double stars and by his thorough acquaintance with the literature of the subject Mr. LEWIS is well qualified for such an undertaking, and the result of his labors is a volume that will prove of great interest and value to all workers in the field of double-star astronomy.

It is natural to compare his work with the two similar volumes that have appeared in recent years—BURNHAM'S General Catalogue of his own discoveries, and HUSSEY'S volume on the Otto Struve Stars. When this is done two main points of difference are at once apparent. Mr. LEWIS has not attempted to remeasure all the stars he discusses, nor even to secure measures of all of them. In many cases DEMBOWSKI'S measures, made thirty or forty years ago, are the last ones given. This, however, is no detriment to the work, for in practically all cases the data given show the nature of the stellar system as clearly as is possible at the present time. Only measures extended over a longer series of years can add information of real value.

The second important difference is the omission by Mr. LEWIS of the references to the original sources of the measures given. Not even a list of the papers consulted in the preparation of the work is printed, so that it is not possible to say, except by comparison with recent astronomical literature, to just what date published measures are included. It is probable that space considerations account for this omission, for it must of course be kept in mind that the present work treats of more than twice as many stars as are contained in BURNHAM'S Catalogue and approximately five times as many as were discovered by OTTO STRUVE; and that as these stars have been known longer, and are for the most part easier objects to measure, the published measures and discussions relating to them bear even larger ratios to those on the β and OΣ stars.

To the present reviewer, however, this omission constitutes a fundamental defect in Mr. LEWIS'S volume, regarded as a work of reference, for any one who wishes to investigate the motion in a given stellar system will desire to consult the original measures in order that he may weight them and combine them in such manner as in his judgment will give the most reliable solution. For the β stars and the OΣ stars he will find a convenient and complete guide to all published data to a definite date in the volumes referred to above, but in the case of the Σ stars he will be no better off in this respect after consulting Mr. LEWIS'S volume than he was before.

To illustrate the fact that no two computers are likely to combine their data in quite the same way, and also to show that the present volume is not exhaustive in point of containing all published measures, I have copied in parallel columns the angle measures of 70 *Ophiuchi* = Σ *2272* for the years 1891 and 1892, as given by LEWIS and as given by DOBERCK in his recent discussion of the orbit in *Astronomische Nachrichten,* No. 4115.

The slight differences in the data common to the two lists are undoubtedly due to differences in the manner of combining the individual measures, and they illustrate my point that every computer will wish to consult the original data when undertaking the discussion of a double-star orbit.

Lewis.		Observer.	Dobberck.	
Date.	Angle.		Date.	Angle.
1891.53	327°.8	...Tarrant.......	1891.53	327°.8
.54	328 .3	...Maw...........	.54	328 .3
.55	325 .1	....H. Struve.....		
.56	327 .6	...Hall..........	.56	327 .5
		...Collins........	.56	329 .3
.58	329 .1	...Schur.........	.58	328 .8
		...Schiaparelli...	.60	328 .5
.61	326 .1	....Bigourdan.....	.65	326 .7
		....Knorre........	.64	327 .2
1892.37	321 .9	...Burnham[1].....	1892.37	321 .9
		...Collins........	.41	320 .5
.42	319 .6	...Knorre........		
.49	321 .7	...Maw.	.49	321 .7
.54	321 .1	...Comstock......	.57	321 .3
.65	319 .1	...Bigourdan.....	.62	319 .3
.63	321 .2	...Tarrant........	.63	321 .2
.64	321 .0	....Schur.........	.64	320 .7
.65	320 .3	...Schiaparelli...	.65	320 .3
		....Glasenapp.....	.68	317 .5
		...Gledhill.......	.69	311 .8

As for the incompleteness of the data shown by this comparison, it is unfortunately true that other stars also show it. For example, in the case of δ *Equulei,* Mr. Lewis has overlooked, among other measures, Hussey's fine series[2] made with the 36-inch telescope on ten nights each in the critical years 1901 and 1902. Nor are all the data given concerning published orbits. The reader, for instance, would infer that Doberck had computed two distinct orbits of η *Cassiopeiæ,* and only two, whereas in his discussion (*A. N.* 3743) he gives a series of six sets of elliptic elements and states that No. VI "must be considered as the definitive orbit, so far." Mr. Lewis quotes Nos. IV and V of those orbits, but curiously enough omits No. VI. Again Doolittle's[3] orbit of Σ 518 has apparently been entirely overlooked.

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[1] In Doberck's article this measure is erroneously attributed to Bigourdan.

[2] See these *Publications,* Vol. XIV, p. 197.

[3] *Proceedings American Philosophical Society,* Vol. XLII, 1903, p. 170.

It is quite unnecessary to multiply such instances, for, after all, they only affect the value of the work as a reference-book, and it is very possible that the author did not plan his work as a reference-book in any sense, but considered it wholly as a discussion of the motions of the Σ stars based on their measures since discovery and of the problems these motions suggest. It is certain, at any rate, that in this discussion lies the value of the work. Every star has evidently been carefully studied, and however opinions may differ as to the validity of the conclusions reached in individual cases, Mr. Lewis's arguments are always interesting and suggestive and his judgments entitled to consideration.

Features of special value are his study of the proper motions, and his analysis of the meridian observations of such stars as ε *Hydræ,* ζ *Herculis,* and γ *Virginis,* which throw new light on the peculiarities shown by the micrometer measures. Another commendable feature is the inclusion of data relating to the spectra of the brighter stars.

New orbits are given for nineteen binary stars, eighteen of which were computed by Mr. Lewis himself and one by Mr. Bowyer. Four of these pairs are not Σ stars, strictly speaking, but are due to the discovery by Otto Struve, Alvan Clark, and Burnham that one member of a wide Struve pair is itself a close double star. Orbits had been previously completed for all of these pairs, and in most cases the new elements do not differ greatly from the former ones. For many other pairs Mr. Lewis gives the apparent ellipse that, in his judgment, best represents the observed motion, but wisely takes a conservative view of the value of these orbits, remarking, for example, that the figure is to be regarded only as a possible representation, or that, while it satisfies the law of equal areas fairly well, too much reliance must not be placed on it.

One of the most suggestive parts of the whole book is Mr. Lewis's discussion in the Introduction of the distribution of double stars in space. Curves are given showing the distribution of the stars in Argelander's D. M. and of the Σ stars. It is seen from the marked similarity of the two curves, with their strong maxima in the plane of the Milky Way, that the distribution of the Σ stars in the sky follows very closely the distribution of the stars in general. But when the Σ stars are divided into classes based on relative motion, and the resulting groups compared, very different curves appear. Thus the curve showing the ratio in each hour of right ascension of the relatively fixed pairs to pairs in relative motion rises to a maximum in the early hours of right ascension and has an equally well-marked minimum in the hours from 16 to 21. A very similar curve results when the fixed physical pairs (i. e. those whose components have a common motion through space but show no relative change) are compared with those showing orbital motion. Mr. LEWIS thinks that "no systematic effect due to observational conditions strongly influenced this curve [No. 3] which deals, not with the absolute number of pairs observed, but with the proportion of pairs of one class to pairs of another class." But he suggests a very simple cause that might alter the proportion of fixed and moving pairs in different parts of the sky—namely, that the stars in certain regions are, as a whole, more distant from us than in others. We cannot follow his analysis of the distribution of the Σ stars based on this conception, but must content ourselves with stating his conclusion, which is that it "seems to show that the stars around us form a universe very much the shape of an egg, and that we are not situated in the center." The longer diameter of this "egg" lies in a line from 3^h to 13^h R. A., and the Earth is nearest the surface of it in about 19^h R. A. He estimates the longer diameter as roughly equivalent to 600 light years, and the smaller to 300 light years. "Professor SEELIGER," he says, "considers the Milky Way in its nearest parts as distant from us some 4,400 light years. If so, the Milky Way evidently lies quite beyond the systems here discussed. It may also be accepted that while the region 3^h R. A. to 12^h R. A. is intrinsically richer in double stars, it is comparatively poor in pairs showing relative motion."

Whether we accept these conclusions or not, their presentation in this form will doubtless stimulate further investigation of the most important problems connected with the study of double stars. To the present reviewer it appears doubtful whether the Σ stars furnish adequate data for their solution, and it was precisely with the object of supplying such data that the systematic survey of the sky for the discovery of new double stars was undertaken at the Lick Observatory some years ago. When this is completed, as it is likely to be within two or three years, it is the writer's hope to be able to discuss these questions anew.

R. G. AITKEN.

September 15, 1906.